Inner tracker simulation

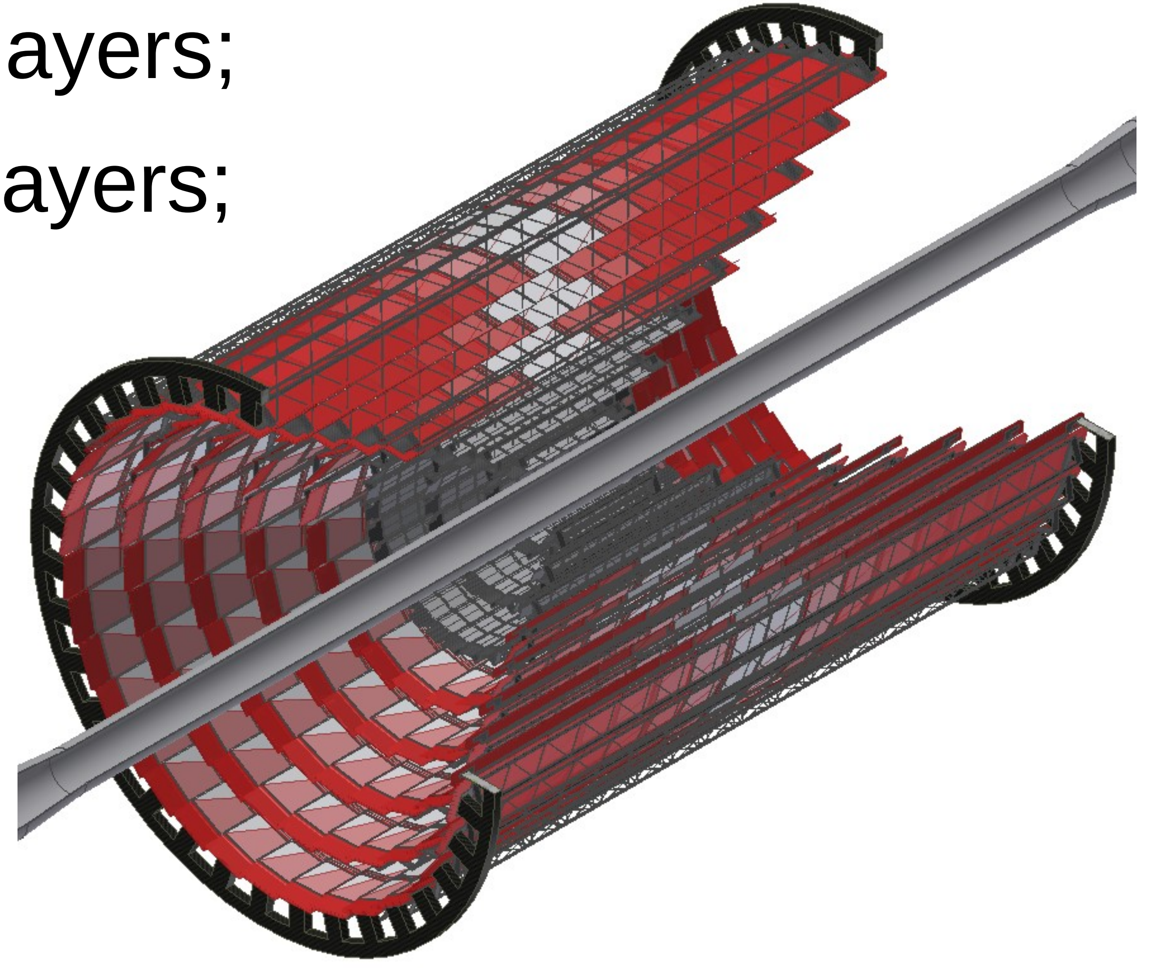
Current status

Requirements to inner tracker

- High radiation tolerance
- Minimum material
- High granularity
- Minimum power consumption
- Efficient cooling
- ....

Tracker parameters influencing reconstruction

- Sensors type (MAPS, DSSD);
- Number of tracker layers;
- Distance between layers;
- Alignment.



Sensors’ parameters

DSSD

Size: 63x63x0,3 mm^3 (on 4” – FZ-Si wafers)

Pitch p$^+$ strips: 95 µm;

Pitch n$^+$ strips: 190 µm;

Stereo angle between p$^+$/n$^+$ strips: 90^0

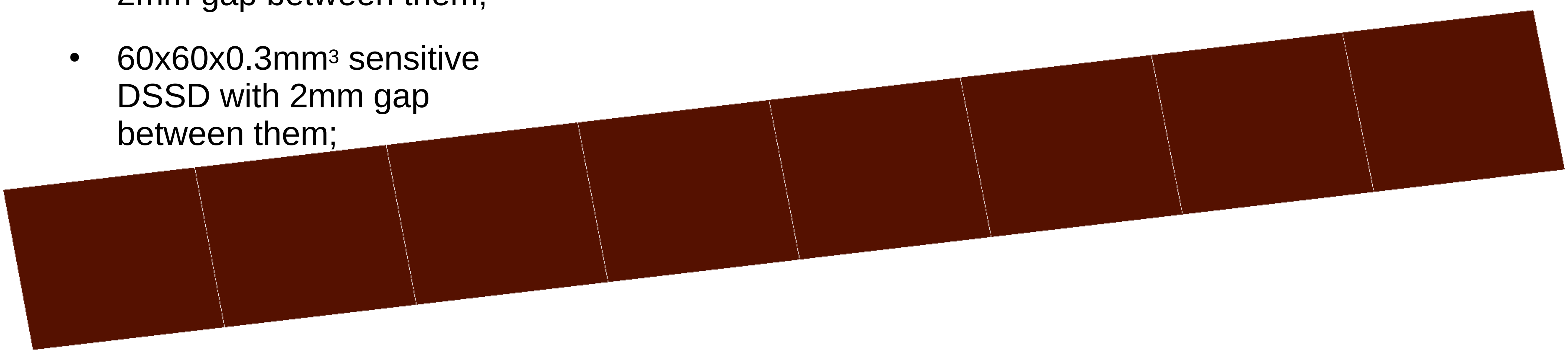
Number of strips: 640 (p$^+$)320(n$^+$)

MAPS

Sensor thickness (µm)	50
Spatial resolution (µm)	10
Dimensions (mm^2)	15 × 30
Number of pixels	512x1024
Time resolution (µs)	30
Detection efficiency (%)	99
Fake hit rate[a]	10^{-5}

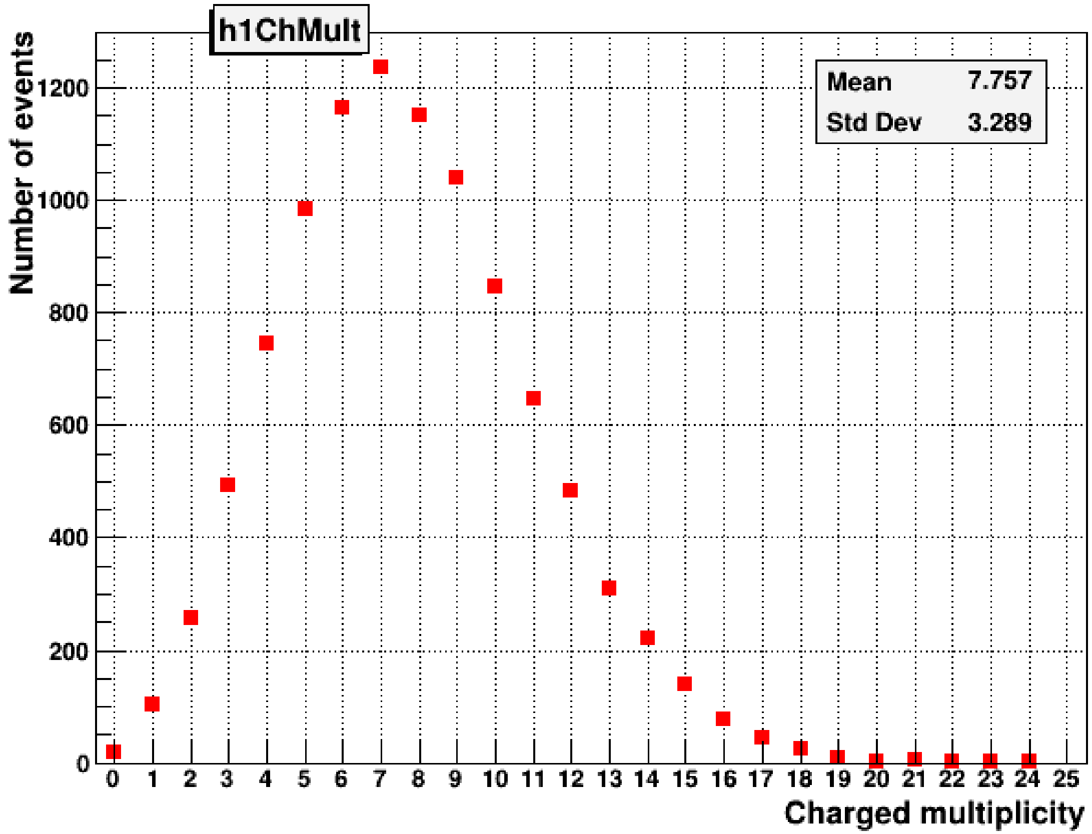
Ladder geometry:

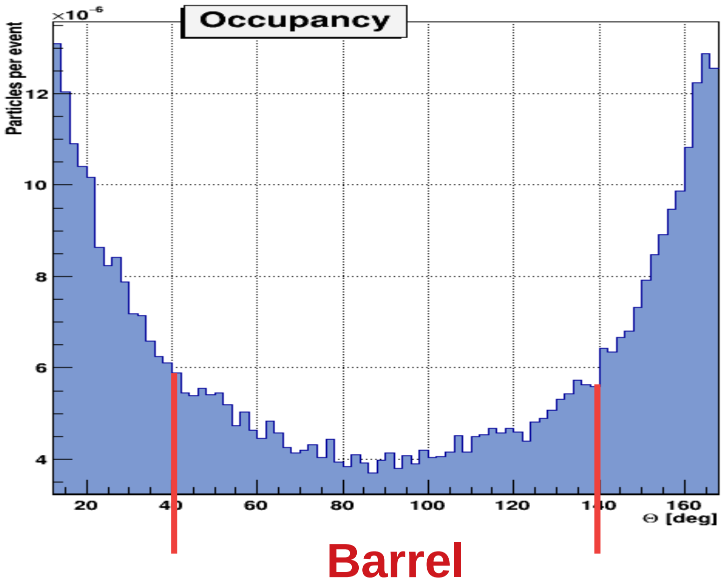
- 15x30x0.05mm^3 sensitive MAPS with 2mm gap between them;
- 60x60x0.3mm^3 sensitive DSSD with 2mm gap between them;



Background

To study background events Pythia6 is used (pp interaction √s = 26GeV, min biased events with central interaction)





Next steps:

- study secondary vertices;
- occupancy per sensor.

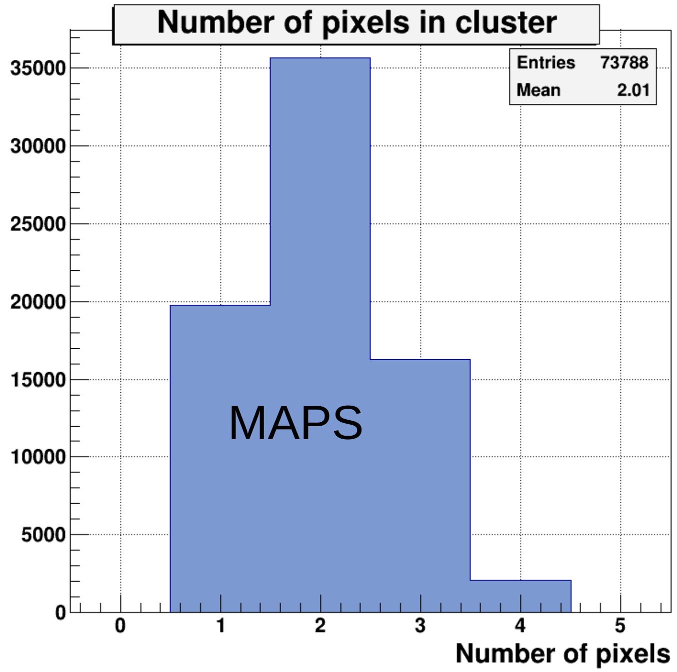
Assumptions

- All tracks are produced in primary vertex located at detector center;
- Hybrid detector setup;
- No magnetic field in inner tracker volume;
- Inner tracker geometry includes only silicon sensors (MAPS or DSSD);
- Ideal clustering;

Hit reconstruction

- At this point clustering is ideal. DSSD doesn't produce ghost hits.
- No magnetic field, thus no Lorentz shift.
- Reconstructed hit position is determined using the relative E_{dep}:

$$u = \sum_i u_i Edep_i^{relative}$$

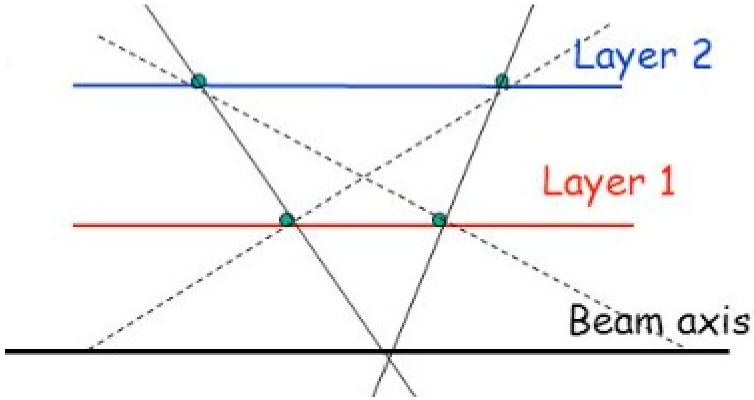


Next steps:

- more realistic digitization;
- fair clustering;
- proper DSSD hit reconstruction.

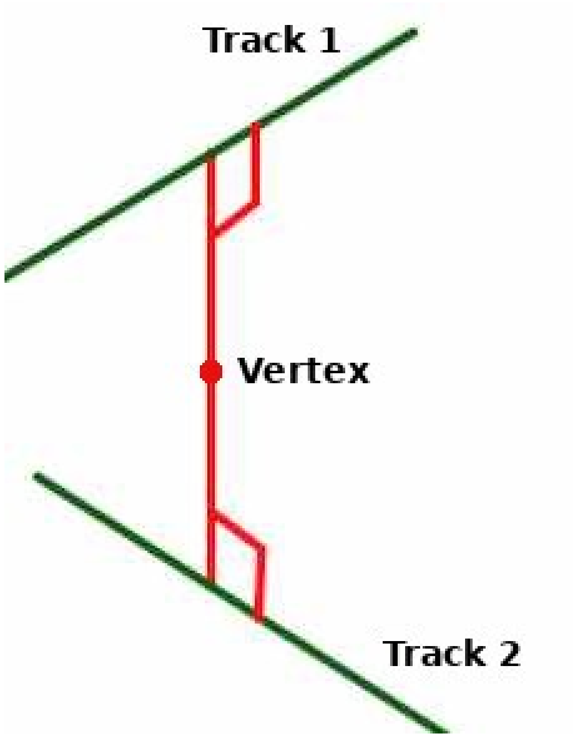
Track reconstruction algorithm

- Find all combinations of hits that have several additional collinear hits;
- Merge tracks that have several common hits;
- Fit tracks using linear least squares



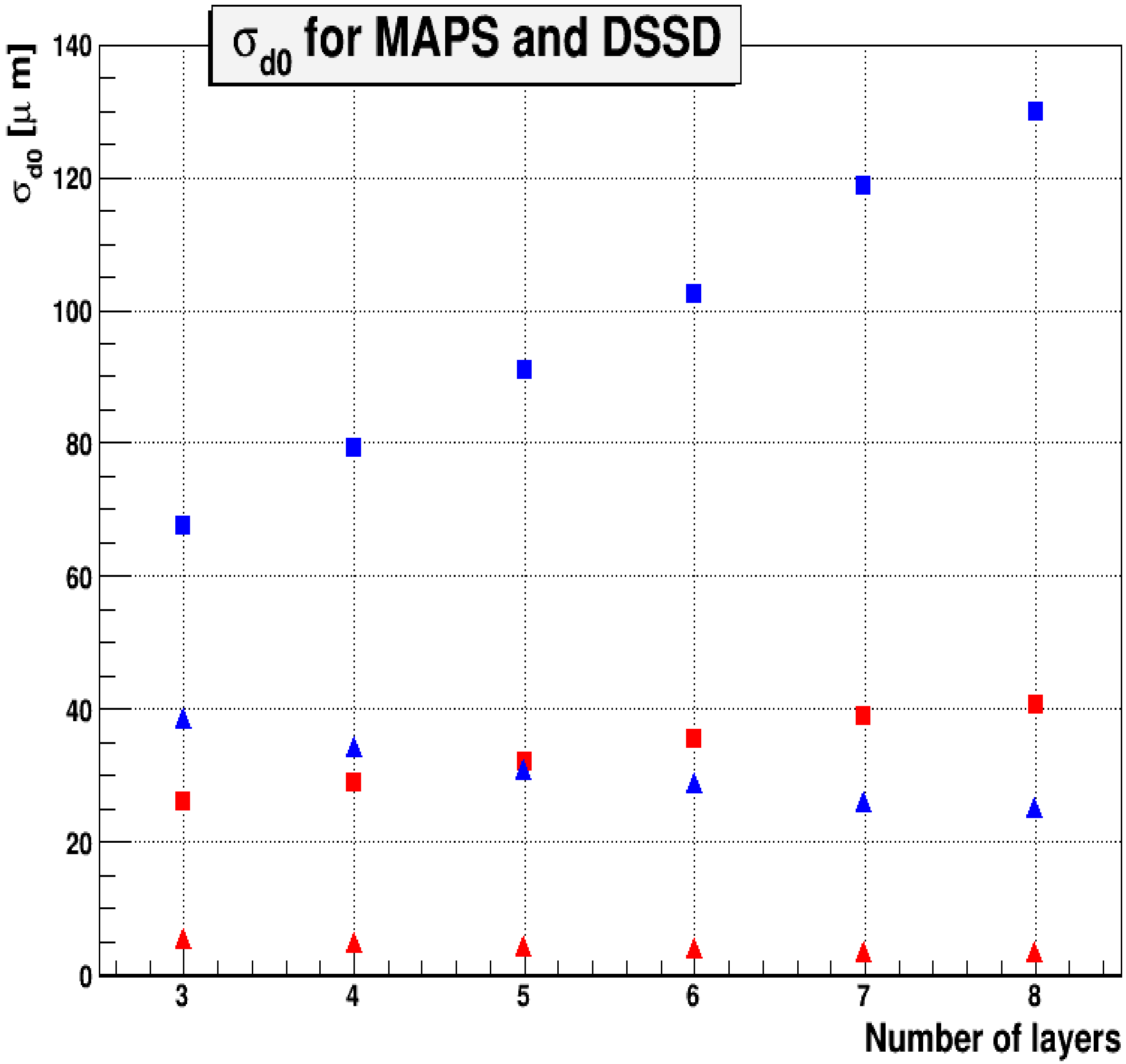
Vertex reconstruction algorithm

- Find perpendicular line for every tracks pair and picking its center as vertex
- Find geometric median of every pair vertex



Impact parameter resolution for different number of layers

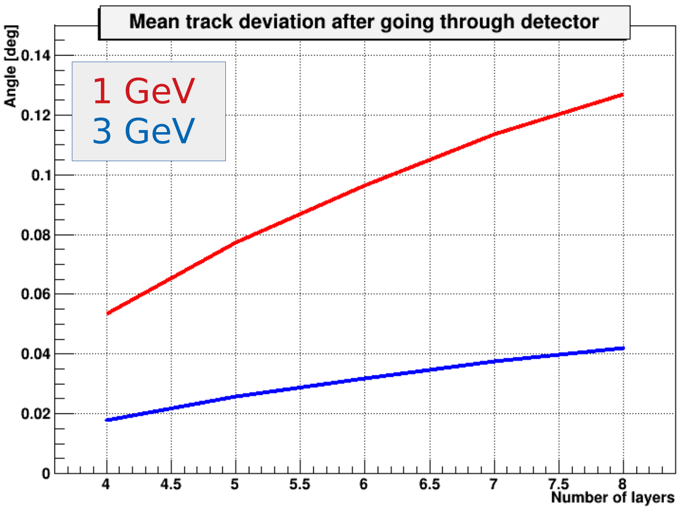
$\sigma_{d0}=f(\sigma_{\text{detector resolution}}, \sigma_{\text{multiple scattering}})$



Squares - σ_{d0} (red MAPS, blue DSSD)

Triangles - $\sigma_{\text{detector resolution}}$ (red MAPS, blue DSSD)

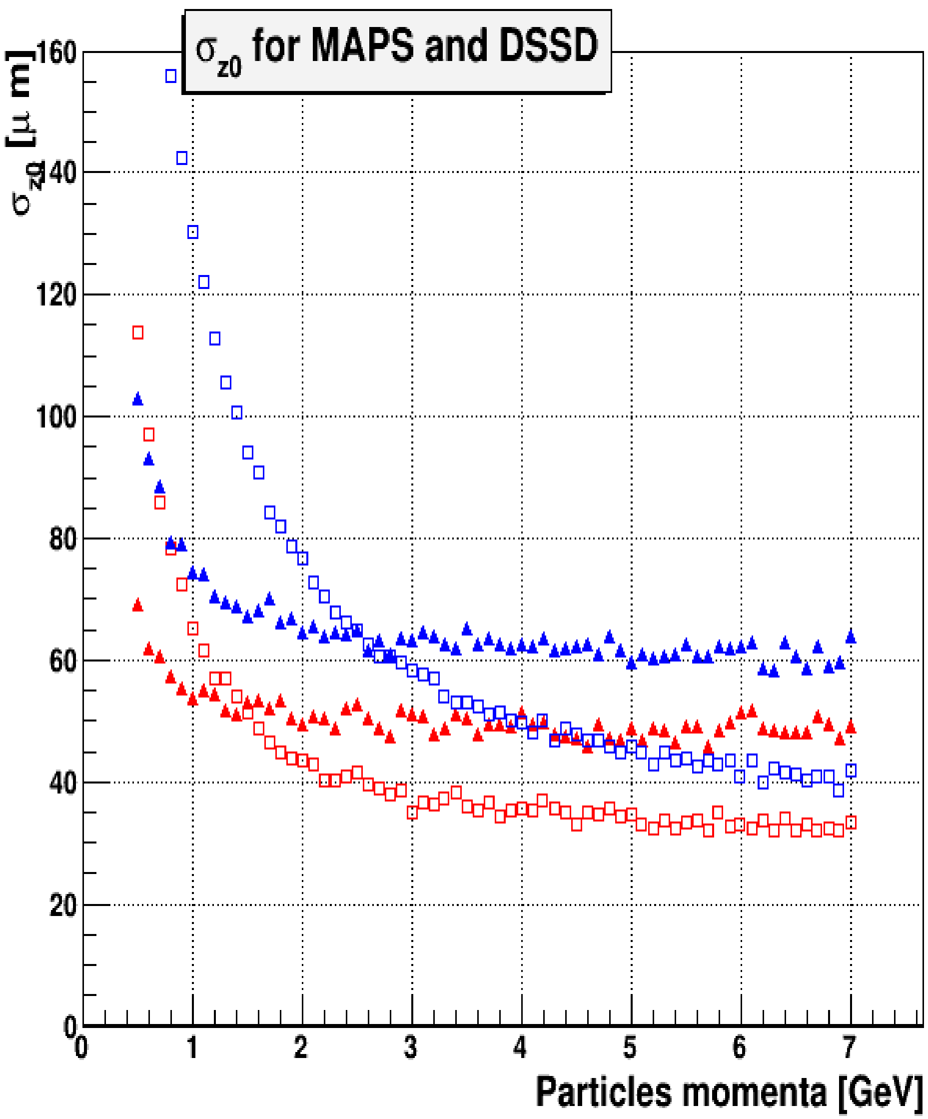
Muon with p = 1GeV

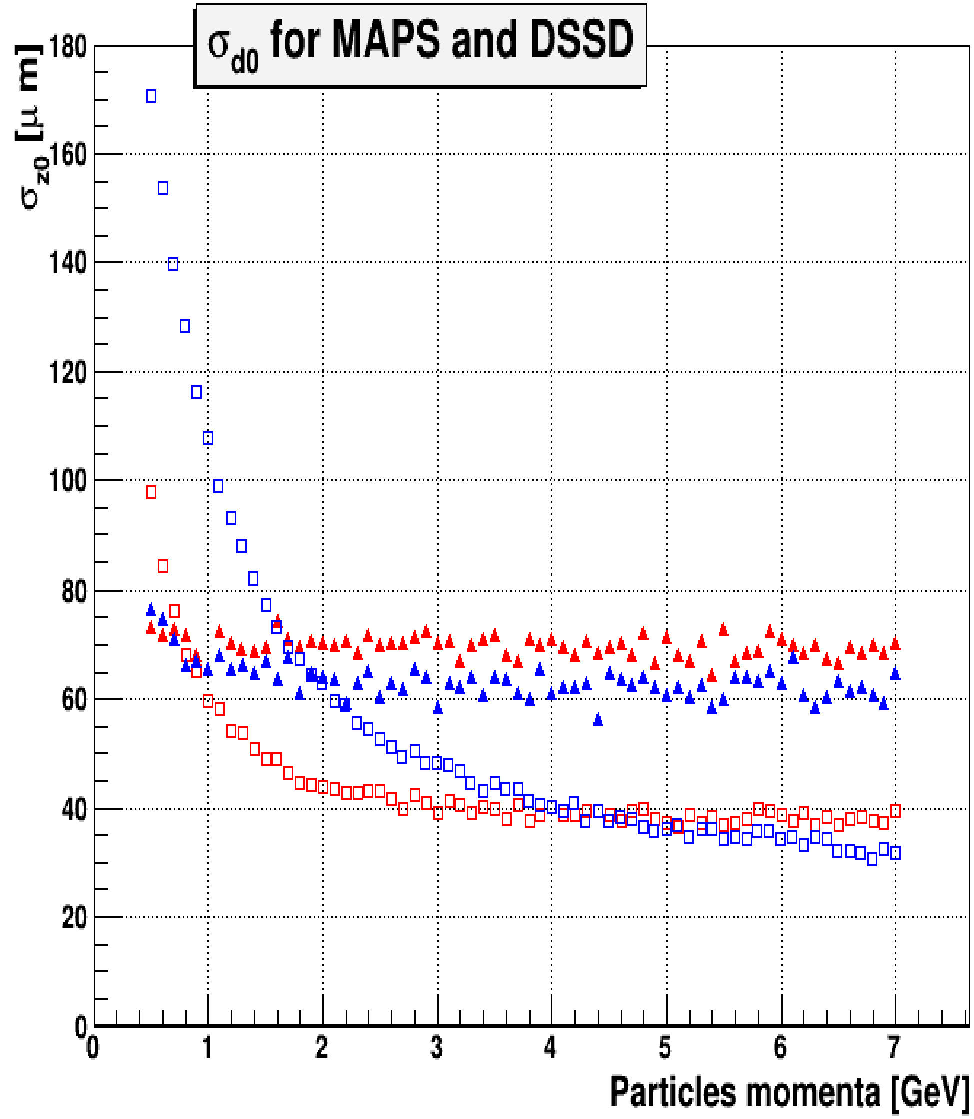


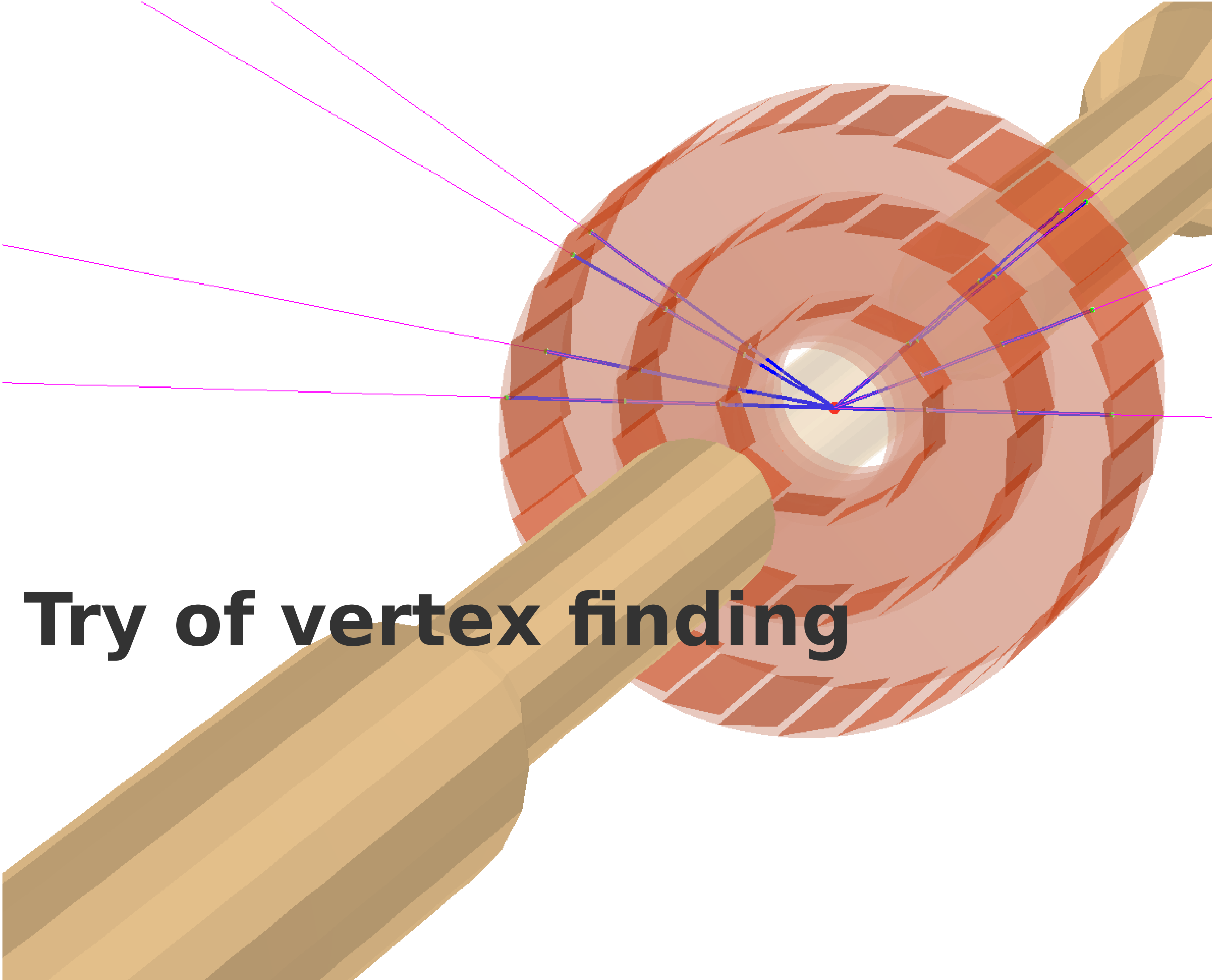
Impact parameter resolution for different momenta

Squares – 8 layers (red MAPS, blue DSSD)

Triangles – 3 layers (red MAPS, blue DSSD)



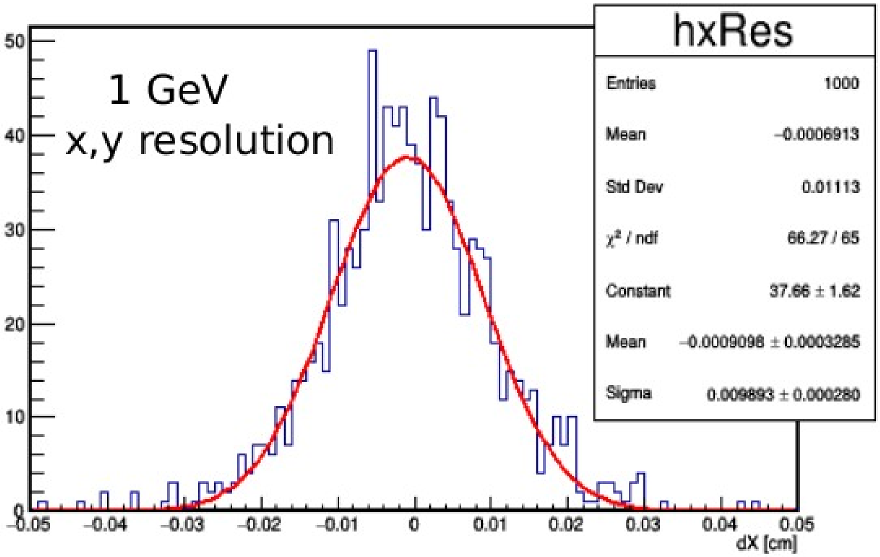


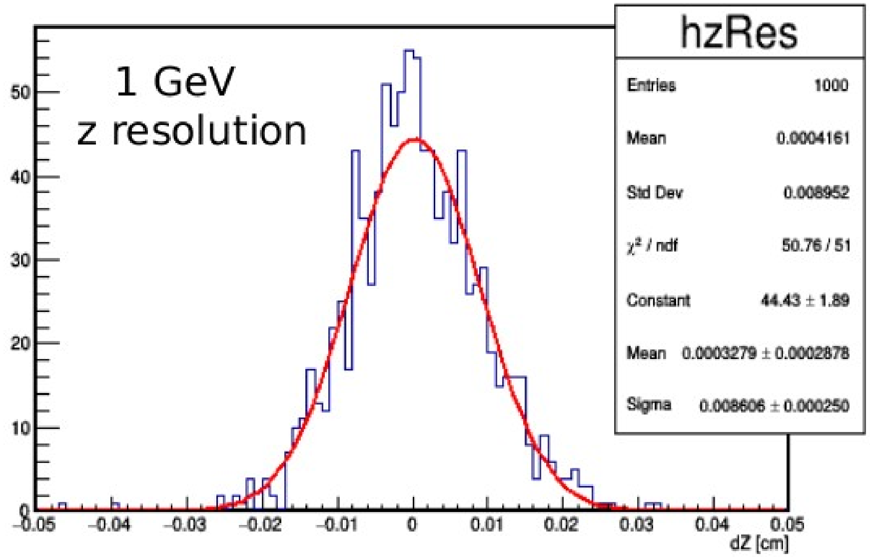


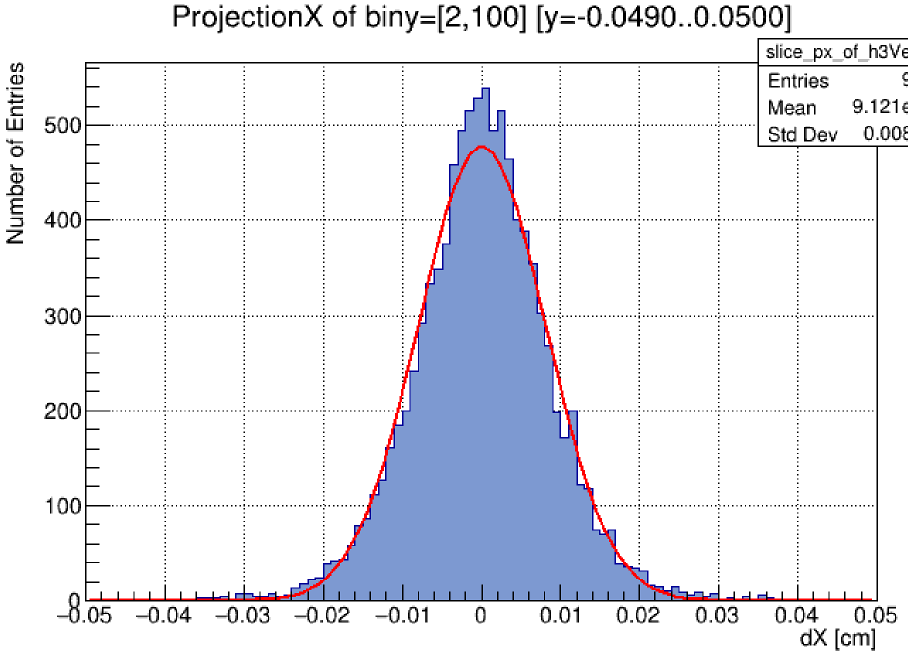
Try of vertex finding

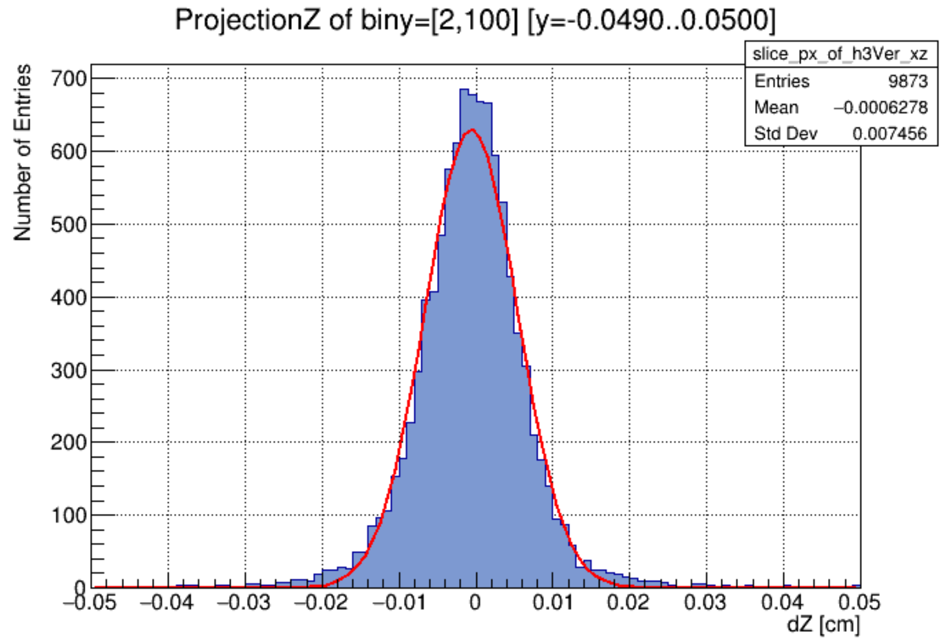
Comparison with Kalman fit

From V. Andreev, S. Gerassimov



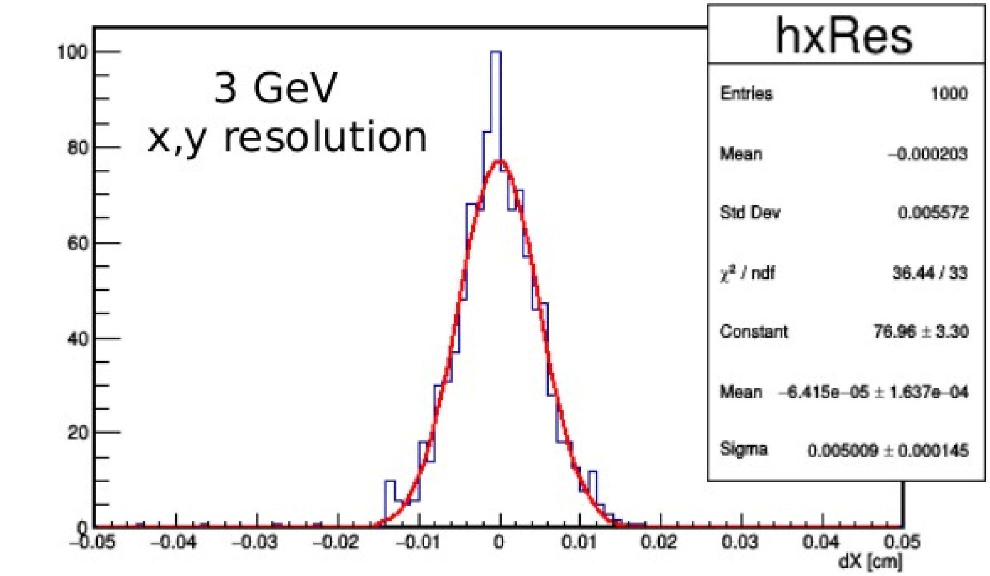


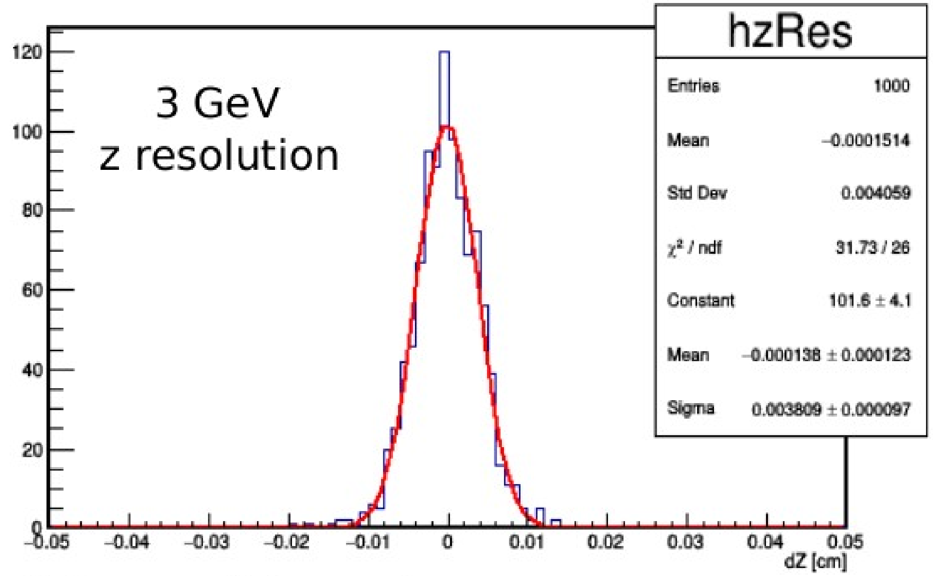


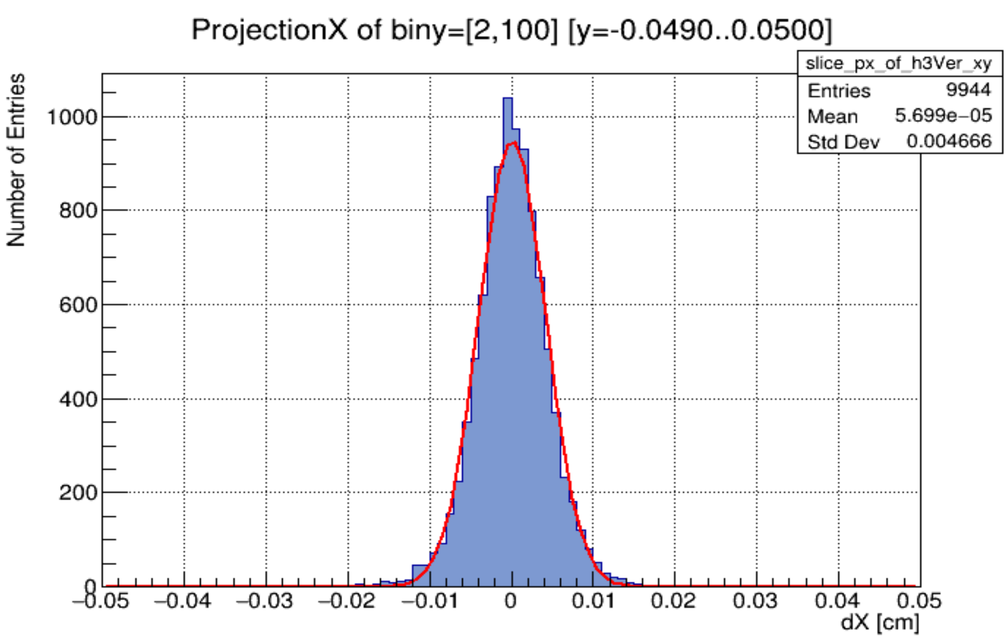


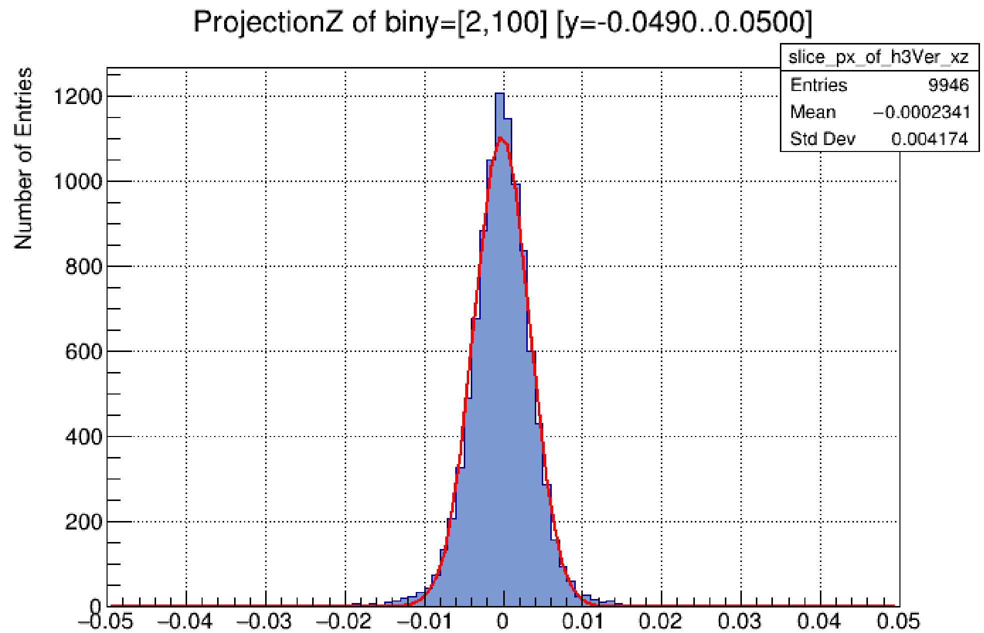
Comparison with Kalman fit

From V. Andreev, S. Gerassimov









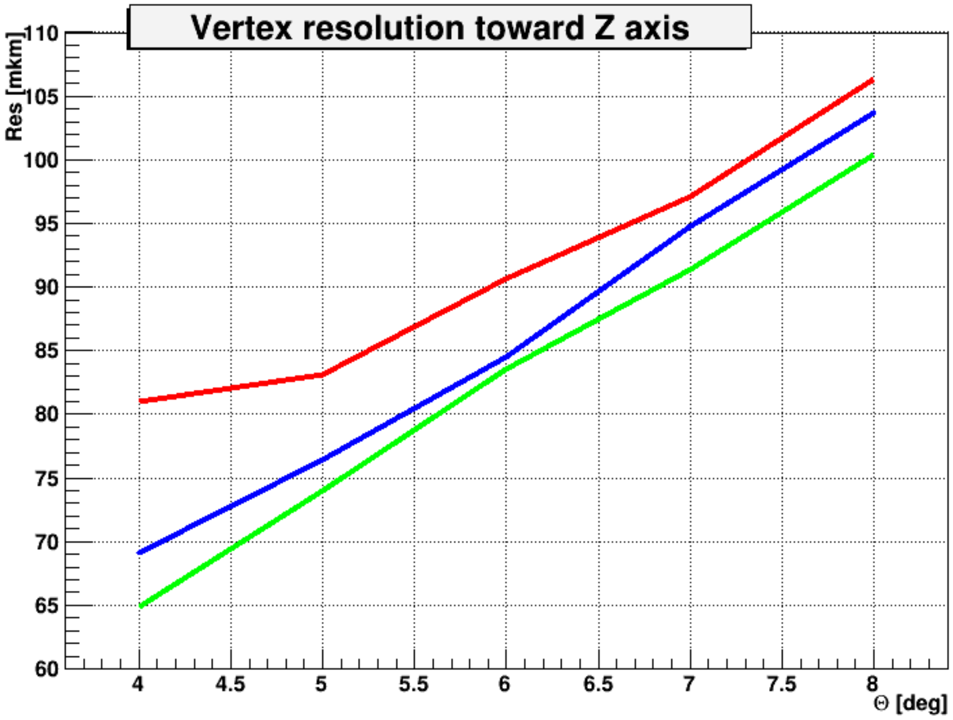
Conclusion

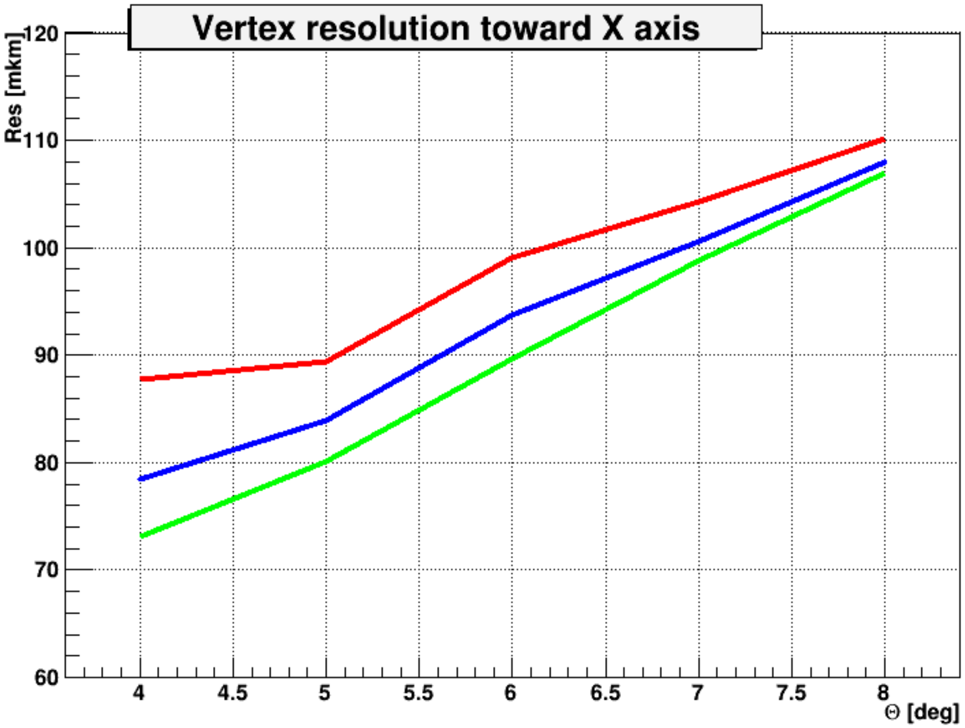
- At this stage presented algorithm can find vertex quite precisely. But with more realistic model results expected to be much worse.
- Further simulation development should more materials, fake hits and other things that decrease algorithm efficiency.
- Next steps should be adding more precise detector geometry and integrating reconstruction algorithm based on Kalman filter developed by Vladimir Andreev and Sergei Gerassimov team

Old slides

Vertex resolution for different number of layers

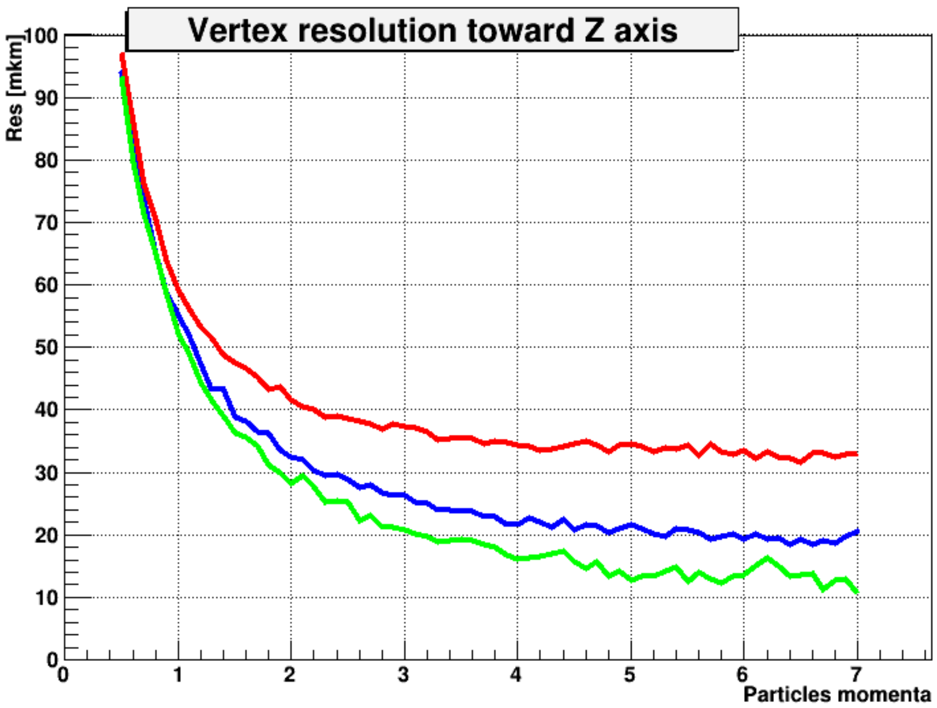
- 6 particles
- Particles momenta: 1 GeV
- Silicon resolution: 50 mkm (red), 25 mkm (blue) and strips combination (green)





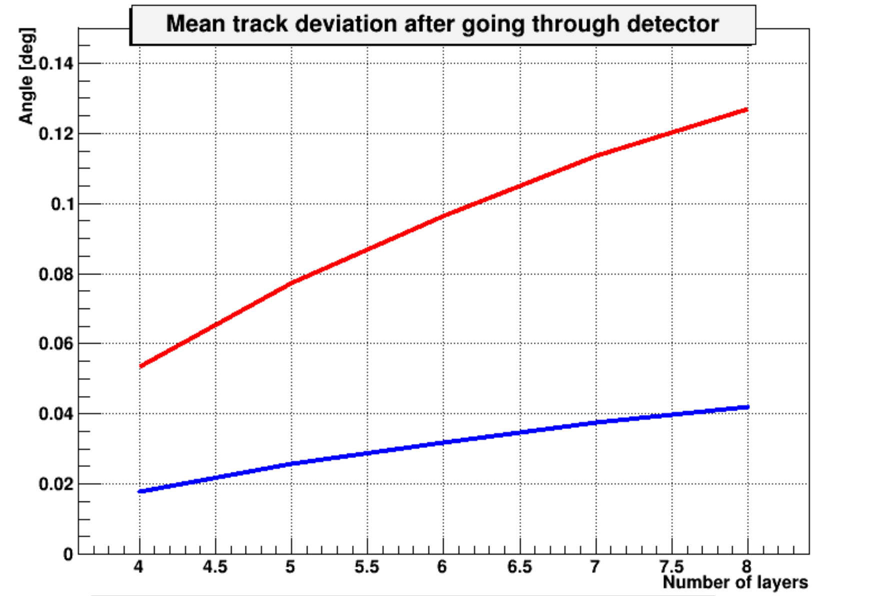
Vertex resolution for different momentum

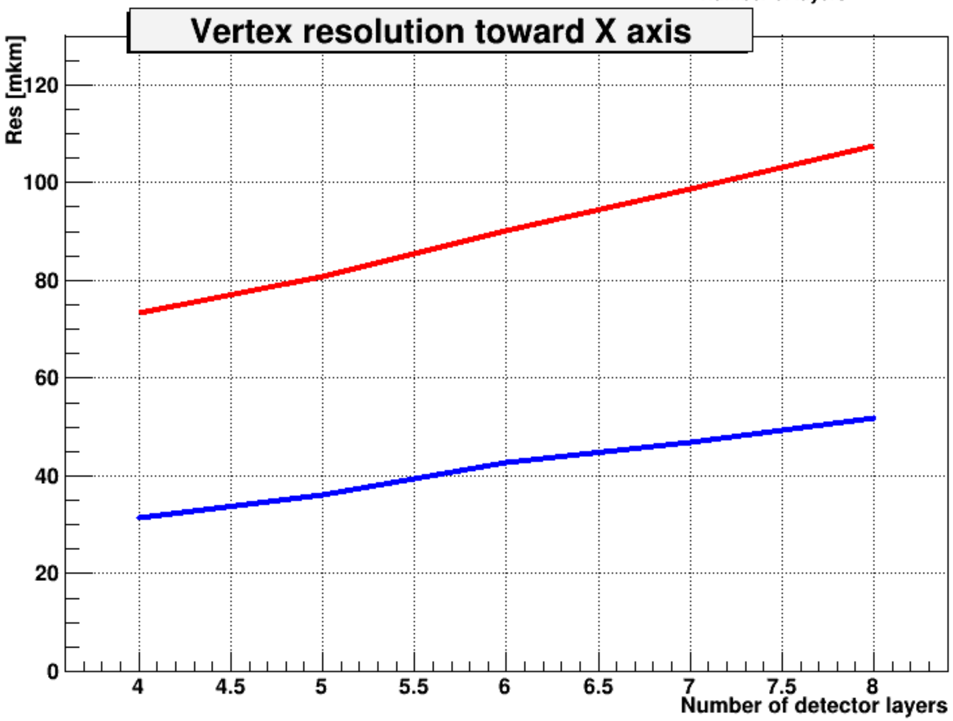
- 6 particles
- 5 Its layers
- Silicon resolution: 50 mkm (red), 25 mkm (blue) and strips combination (green)



Vertex resolution for different number of layers

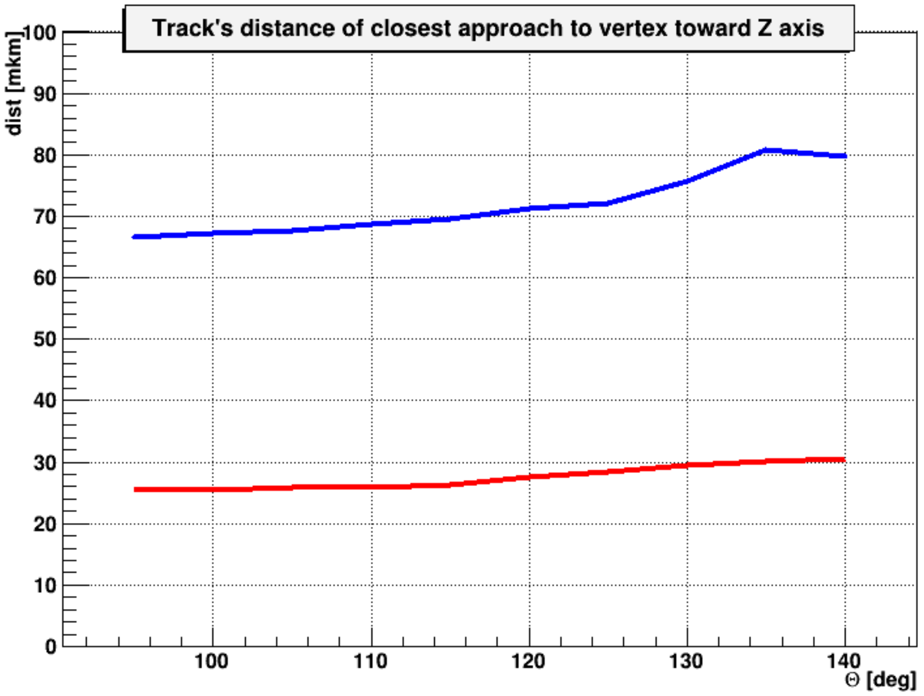
- 6 particles
- Particles momenta: 1 GeV
- Particles momenta: 1 GeV (red) and 3 GeV (blue)

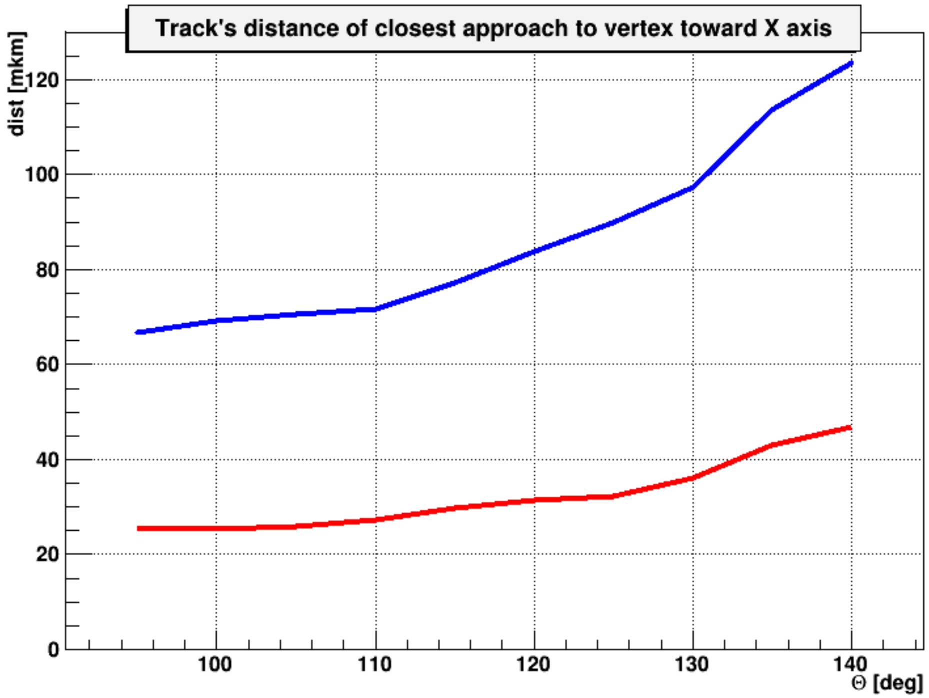




Track's distance of closest approach for different polar angle

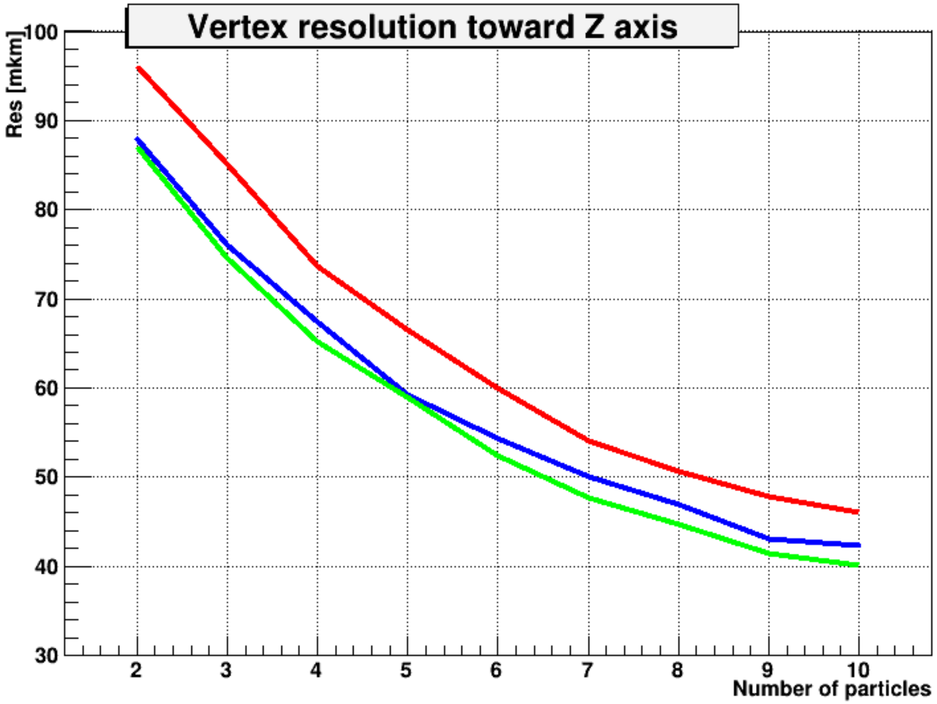
- 1 particles
- 5 Its layers
- Particles momenta: 1 GeV (blue) and 3 GeV (red)

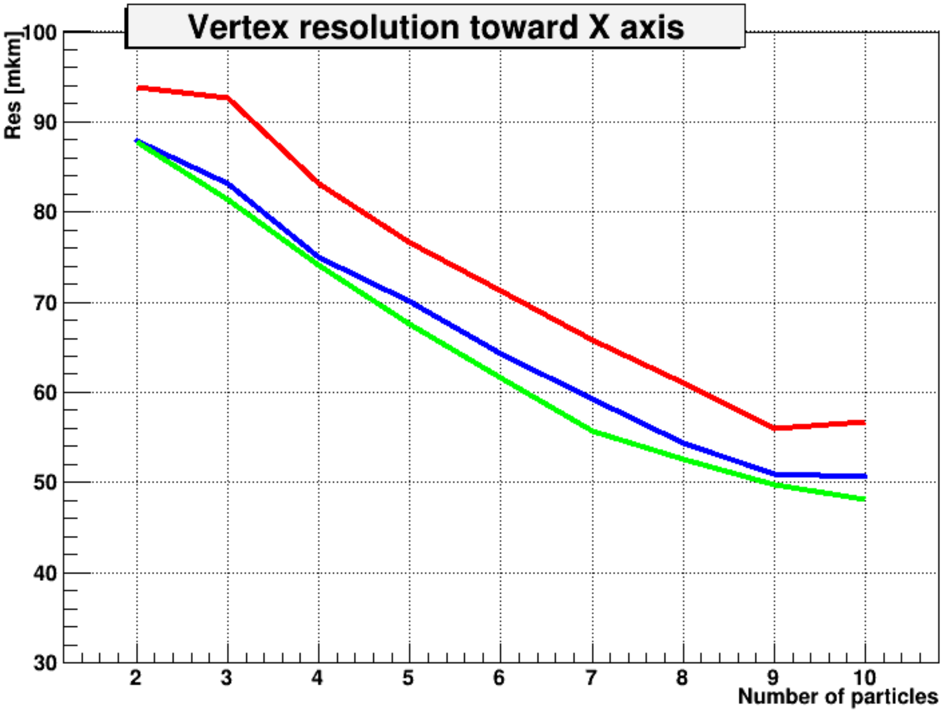




Vertex resolution for different number of particles

- 5 Its layers
- Particles momenta: 1 GeV
- Silicon resolution: 50 mkm (red), 25 mkm (blue) and strips combination (green)





Current inner tracker geometry

From N. Zamyatin

	Number of Sensors per ladder	Number of ladders	Number of Sensors	Area, m^2 ***Area of 1 MAPS 4,5 cm^2 Area of 1 DSSD 40 cm^2***
1 layer – MAPS	10	12 (L=150 мм)	10×12 = 120	0,054
2 layer – MAPS	18	20 (L=270 мм)	18×20 = 360	0,162
3 layer – MAPS	26	28 (L=390 мм)	26×28 = 728	0,327
4 layer – DSSD	8	19 (L= 496 мм)	8×19 = 152	0,603
5 layer – DSSD	10	23 (L=620 мм)	10×23 = 230	0,912
6 layer – DSSD	12	27 (L=746 мм)	12×27 = 324	1,285
7 layer – DSSD	14	31 (L=870 мм)	14×31 = 434	1,722
8 layer – DSSD	16	35 (L=996 мм)	16×35 = 560	2,222
Total for barrel			Number of MAPS = 1208	Total area MAPS =0,54 m^2
			Number of DSSD = 1700	Total area DSSD = 6,74 m^2

Layers number

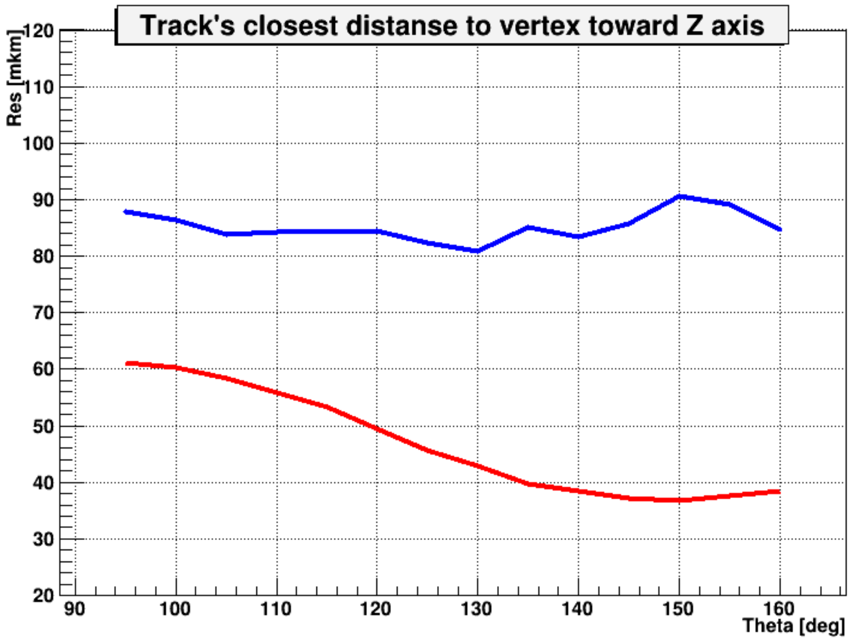
- Muon pair with p=1GeV

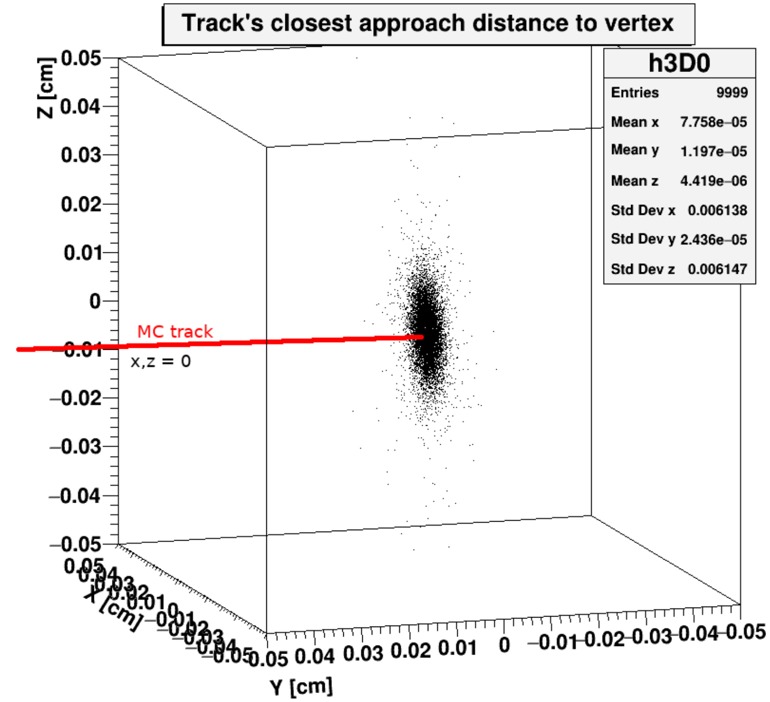
Hits in track equals number of layers:

Layers	5	6	7	8
Tracks reco eff	0.944	0.918	0.896	0.8694
Verteces reco eff	0.892	0.843	0.803	0.7558
Mean d0, [mkm]	214	234	261	291
Std dev d0, [mkm]	214	226	240	257

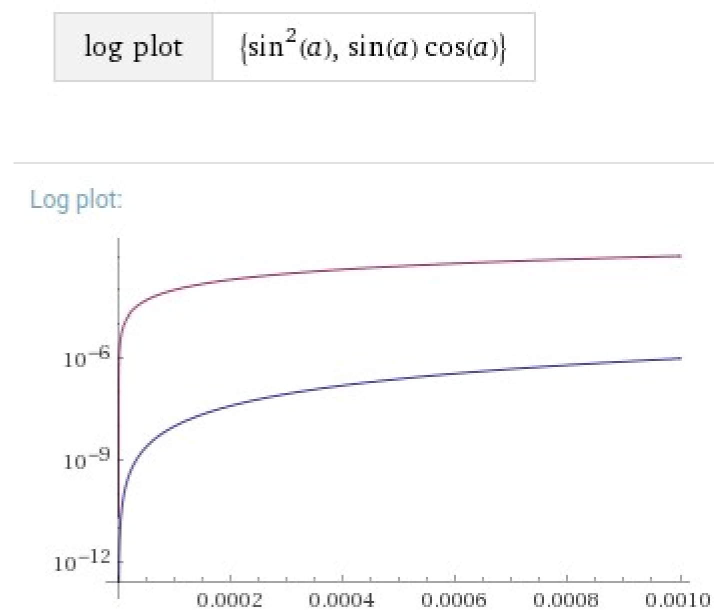
Hits in track equals number of layers minus one:

Layers	5	6	7	8
Tracks eff	0.99995	0.999	0.995	0.996
Verteces eff	0.9995	0.998	0.991	0.991
Mean d0 [mkm]	215	233	260	285
Std dev d0 [mkm]	215	227	238	252





Z0~sin²(a)
d0~sin(a)cos(a)

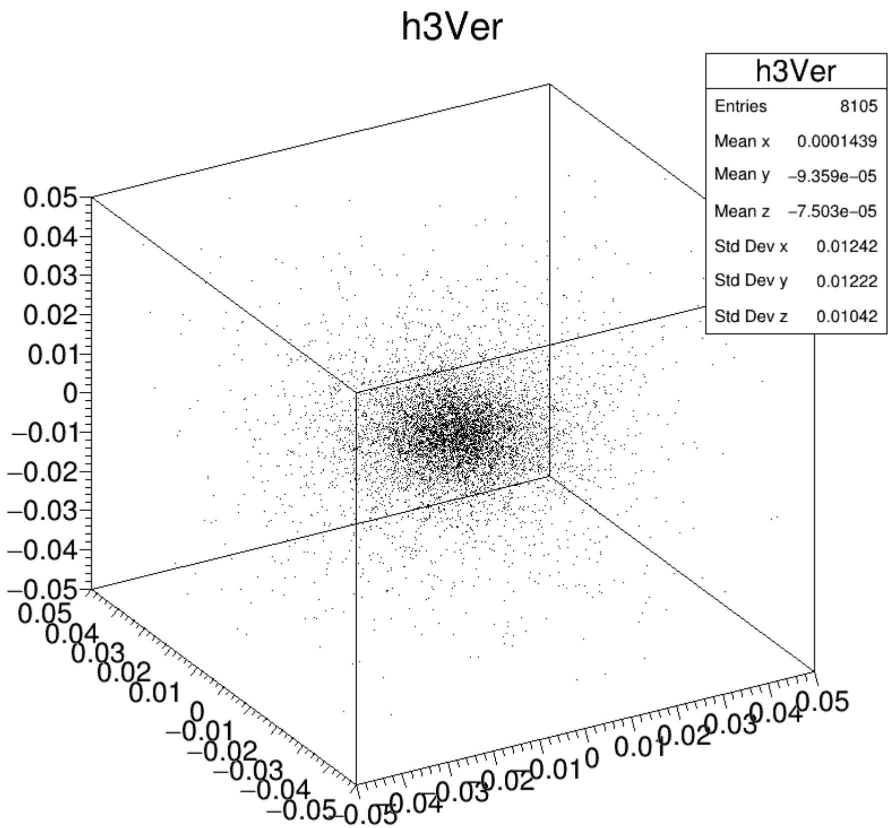


a [rad]

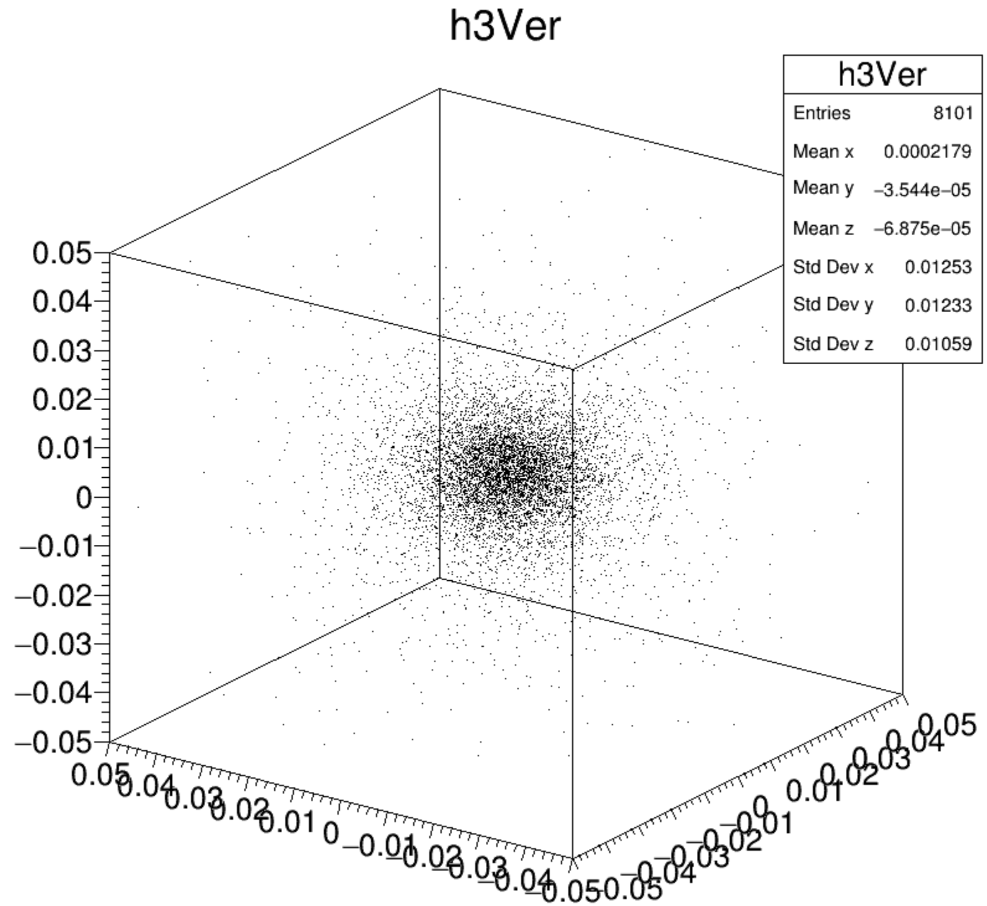
Effect of MAPS and DSSD resolution

- Muon pair with p=1GeV
- 5 layers
- Min 5 hits

Ideal hits



Smeared hits



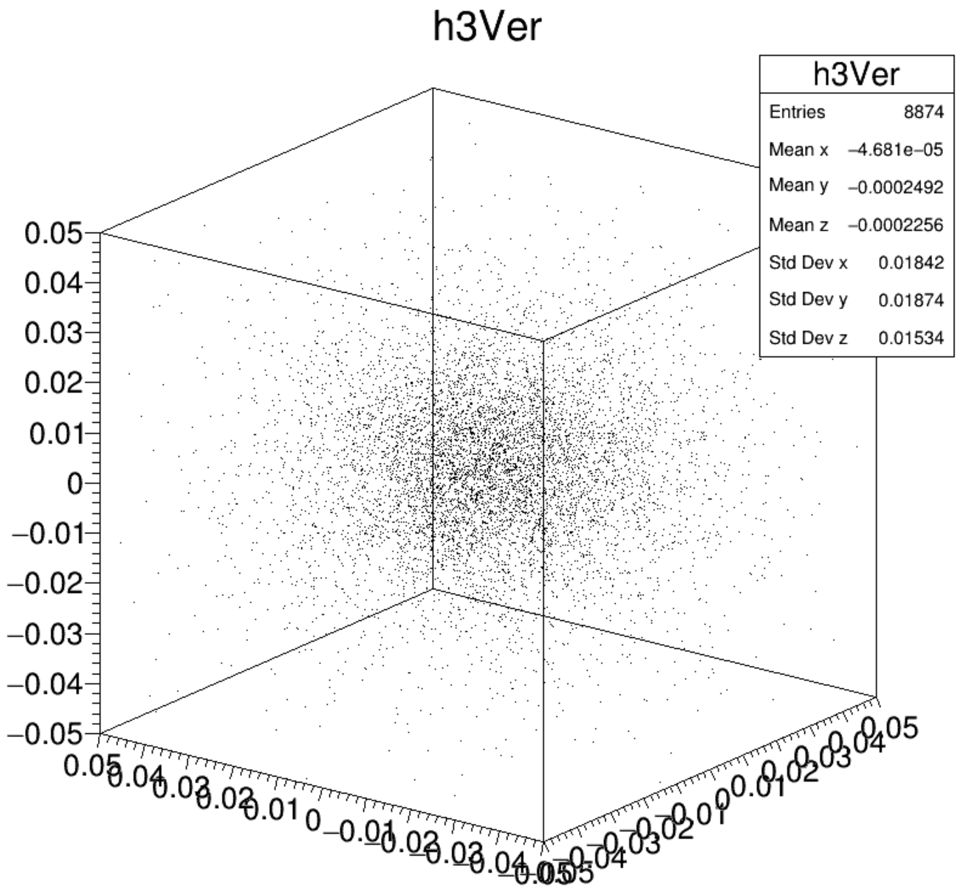
TracksRecoEff: 0.9001
VertecesRecoEff: 0.8105

TracksRecoEff: 0.89985
VertecesRecoEff: 0.8101

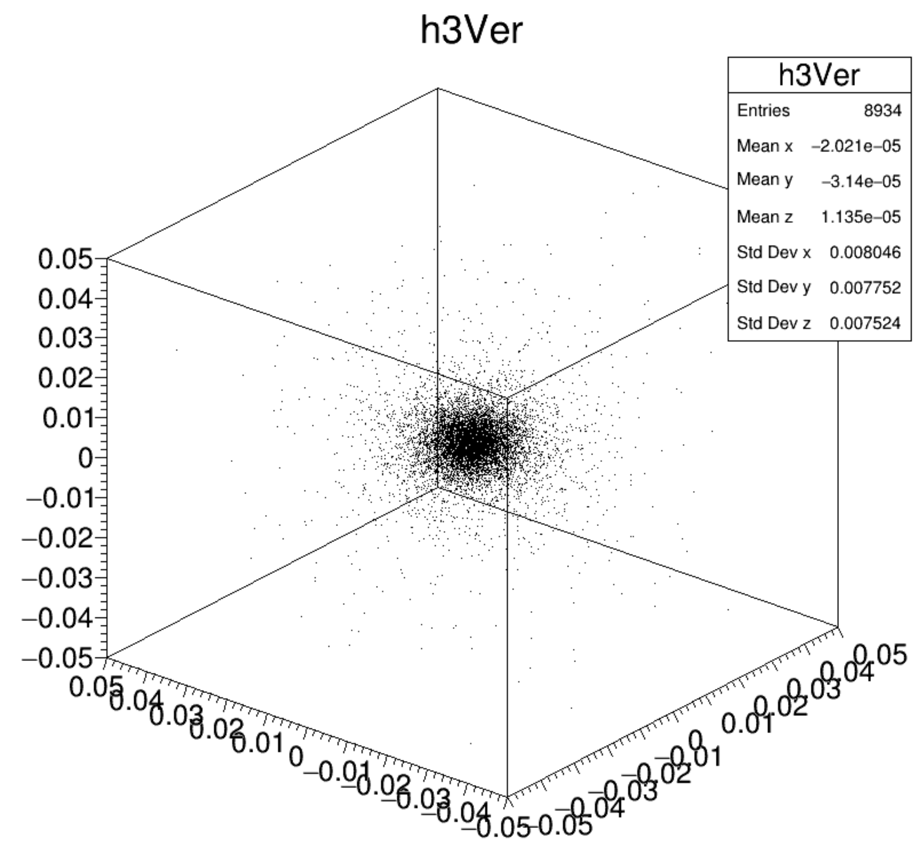
Different momenta

- Muon pair
- 5 layers
- Min 4 hits

P = 0.5 GeV



P = 2 GeV



TracksRecoEff: 0.9425
VertecesRecoEff: 0.8874

TracksRecoEff: 0.9456
VertecesRecoEff: 0.8934